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A commentary
Research methods for the advancement of possibility knowledge and practice in science and engineering education

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It was in the year 2005 when I first heard a children's story on "Seven Blind Mice" by Ed Young (1991) in connection to a talk given by Dr. Ralph Cordova at the University of California, Santa Barbara. The story retells in verse the Indian fable of the blind men discovering different parts of an elephant and arguing about its appearance. This metaphorical story created an important rich point for me academically to further my personal learning journey in searching, developing and making sense of different ways of researching and understanding discourse, knowledge and social practice in educational settings, and the possibilities and limitations each strand of research entails for informing educational theory and practice (see also Green, Camilli, & Elmore, 2006). Most importantly, this story inspired me to explore research approaches in education whose logic-of-inquiry would allow researchers to move beyond a narrow and one-sided focus of analysis, towards acknowledging part-whole relationships and micro-macro level dynamics of educational processes and the opportunities such an approach can afford for unpacking engagement, learning and identity building among the participants.

All those who have conscientiously read the chapters of this volume are most likely to agree that the studies and their logic-of-inquiry create a set of compelling academic narratives for educational researchers interested in the study of everyday life in science and engineering classrooms as situationally constructed in and across space and time. The studies zoom in and out of the everyday life of science and engineering classrooms conveying insights regarding specific cultures of learning - how they are relationally and iteratively constructed into being, maintained and transformed in situ and over time. Altogether, the studies illustrate the expressive potential (Strike, 1974) of the so called the *interactional ethnographic* approach (Green & Castanheira, 2012) to address many complex goals and challenges of contemporary science and engineering education.

This approach takes serious and systematic account of part-whole relationships and micro-macro level analyses of educational processes, somewhat similar to the story of seven blind mice and their collective sense-making and discovery of the strange Something, the elephant.

These rich set of studies of discourse discussed in this volume all make visible how classroom interactions are sites of social construction of science and engineering content, processes and practices. Grounded in ethnographically informed logic-of-inquiry, interactional sociolinguistics and sociocultural theories of learning, that account for the interactional ethnographic approach, each chapter of this volume approaches science and engineering education as interactional accomplishments situated in sociocultural contexts with a goal of shedding light into how, in what ways, for what purposes, and with what outcomes and consequences science and engineering education and learning are socially, discursively and conceptually constructed in and across space and time.

Altogether, the studies of this volume create powerful narratives that convey insights into the everyday activities, practices and cultures of science and engineering classrooms, and how these are interactively and iteratively designed, implemented and maintained. We can view these studies from the perspective of *choronotopes* that direct attention to times and spaces through which particular types of educational processes and opportunities are made possible in the continuum of the past, present and future. The notion of chronotope originates from the works Mikhail Bakhitin (1981), a dialogic literary scholar, who used the concept to describe the contextual grounding of events in a literary narrative, that is, the unity of time and space. Here, space and time are not seen as neutral abstractions or as a background or a passive context in which activity occurs but as socially constructed, intrinsically interconnected and imbued with cultural meanings and practices, values, and ideology (Morson & Emerson, 1990). Hence, chronotopes are actively constructed in social interactions within and across sociocultural contexts. In sum, drawing on Bakhtin (1981), we can define chronotopes as socially constructed time-space configurations with a specific narrative character that represent cultural practices and values, and that operationalize the framing of the interactional situation and its actors (Kumpulainen & Rajala, 2016). Specifically, chronotopes index the relative changeability of the social world, the opportunities for individual agency, and the relations of social and individual development as each chronotope relates actors, actions, and contexts in specific ways, as illuminated by the studies of this volume.

The study of McDyre addresses a timely and societally relevant chronotope to science and engineering education that is to do with the ways in which females are positioned in science

education. Drawing on interactional ethnography the study shows how young kindergarten children participated in science, which norms were established in the classroom and how girls were positioned in terms of learners of science. Her empirical data consist of longitudinal, two yearlong video recordings of student discourse, student interviews, ethnographic field notes, photographs of student science notebooks and additional artifacts, teacher informal interviews and a guardian questionnaire. These multiple methods were deemed pivotal in order to gain an emic understanding of the dynamic interactional processes for students' positioning and identity building. Alike to the other studies of this volume, characteristics of this work is its generative nature resulting in new questions and insights in conceptualizing, understanding and researching girls positioning, identity building and educational opportunity in science.

In the chapter of Vanderhoof, research attention is directed to investigating how young children attending third grade (8 years old) negotiate uncertainty in their groups in situ and over time in civic engineering. The study pays specific attention to how the children's positioning of self and others affected their decision-making processes in a group. Informed by interactional ethnography which is enriched by a multimodal approach, the study entailed careful reading and inductive, interactive and recursive analysis of rich multimodal data from different angles and timescales. Each phase and layer of analysis added extra background knowledge about the participants, their changing group roles and the developing final project. In doing so, the study unpacks the chronotopic character of the students' management of uncertainty, resulting in nuanced and situated research knowledge about the opportunities for these children's science learning. Overall, the study challenges those methodological approaches that draw upon pre-defined and de-contextualized categorizations of productive/unproductive dichotomy in understanding educational opportunity.

The study of Licona communicates a compelling narrative of the chronotope of equal educational opportunity in reform driven science education among culturally and linguistically diverse students. Drawing on interactional ethnography, the study narrates the implementation of a socio-scientific approach to science education coupled by a scientific argumentation framework in an English-Spanish dual language middle school science classroom. The study demonstrates multiphase, recursive and consequential data collection and analysis processes, entailing macro-level analyses that zoom over the norms and expectations of the communicative settings, and micro-level analyses of selected interaction episodes. The study speaks to the importance of creating inclusive interactional spaces for diverse learners to engage in and learn about scientific and epistemic practices and their discourses, and the meaning of teacher translanguaging in this process. In

addition, the study shows how interactional ethnography transformed the role of the researcher and the teacher, resulting in a co-expertise model in which research on the classroom culture was done "with" the teacher, instead of "on" the teacher.

The study by Johnson illustrates the expressive potential of interactional ethnography accompanied by the sociomaterial perspective to investigate the social construction of failure and improvement as they are socially constructed into being in the interactions of students, teachers and materials in the context of engineering design projects. The study draws on longitudinal research data involving large video data sets of classroom interaction, discourse and student journals. The chronotope addressed by this study deals with the contextual grounding of failure and its consequential negotiation for improvement at the nexus of discourse, social practice and use of material artefacts. Not only does this study demonstrate how failure and improvement take place in situ but also contribute to a nuanced understanding of the meaning and value of failure in the learning of science and engineering, and how teachers can build on failure as a learning opportunity.

In their chapter, Sezen-Barrie and Mulvaney take us to an ethnographic research journey on how teachers and students draw from an interdisciplinary area of climate science to make sense of human-caused contemporary climate change, namely the uses of alternative energy sources. The study looks into the discursive interactions among a team of professionals, namely a scientist, a mathematics instructor and educational researcher, during their joint development of a mini-unit on climate change as part of a university level course for secondary education majors. Research attention was directed to discursive interactions manifested in written reflections and feedback, and email exchanges within the development team, and how these interactions supported or constrained decision making in incorporating interdisciplinary knowledge and practices into the unit. Another set of data in this study is embedded in the actual classroom implementation of the mini-unit, entailing video-records of classroom interactions, records of instructional tools, formal assessment probes, students' written artifacts and field notes. The iterative, recursive and consequential analyses of these diverse data sets reveal a chronotope that illuminates how frame clashes between diverse interdisciplinary discourses not only diminish but can also enhance conceptual and epistemic coherence in making sense of climate science and climate change.

In her chapter, Hufnagel introduces yet another chronotope by focusing on the social construction of emotions within the collective action and cultural norms of the science education classroom in the context of climate change. Hufnagel argues that although emotional sense-making is an

important component of making sense and taking action on climate change, science is still often characterized objectively with little attention to directed to emotional ties between humans and nature. In order to study emotional sense making in an environmental science course on climate change, she directs her research attention to students' *emotional expressions* in situ, investigating how these are conveyed in talk and text through interactional, contextual and intertextual features at the nexus between the individual-collective and the individual-within-the-collective scale. Similar to the other studies of this volume, the logic of inquiry was grounded in the ethnographic research cycle (Spradley, 1980) that entailed investigating the culture of the classroom as a participant observer through an abductive, iterative, and recursive process, attending to the cultural behaviors, cultural knowledge, and cultural artifacts within the class community (Agar, 2006). This study makes also visible how this project and its goals developed and shifted overtime generating new data sets to answer further questions.

The chapter of Ozcelik and McDonald discusses how preservice teachers and their instructor co-constructed a new, reform-based teaching model in science education. In specific, the study communicates a chronotope that unpacks how preservice teachers develop a professional vision for ambitious science teaching. Drawing on interactional ethnography, the data collection included following preservice teachers across several science teaching methods classes and field experiences over time, and relying on a number of data sources including participant observation, ethnographic field notes, video-recordings, interviews and collected artefacts and documents from the courses. These data sources were analyzed at macro and micro levels, zooming in and out of the data to unpack complex and multi-layered contexts of professional growth across space and time. Altogether, this study sheds contextual light into chronotopes that mediate preservice teachers' construction of professional vision.

The chapter of Ricketts deals with professional discourses in science teacher learning groups. In particular, the study is motivated to generate research knowledge how teachers' conversations around practice mediated their opportunities to learn about teaching science, with a specific focus on generative teacher talk. By harnessing interactional ethnography, the chapter makes visible the cultural actions, knowledge and artifacts that teachers use, produce, predict and interpret during their engagement in the teacher learning group. The analyses of longitudinally collected video-records of the teacher group meetings, teacher interviews and observational field notes proceeded iteratively and recursively. The analysis consisted of identifying and representing key events, defining emergent analytic focuses, identifying relevant unit of analyses and constructing

explanations relevant to this specific sociohistorical and cultural context (Kelly, 2014). This study and its logic-of-inquiry allow us to gain access to designed and more serendipitous aspects that mediated the construction of generative talk and learning opportunities in teacher groups. These findings account to the chronotope of teacher learning as relational, situated and consequential.

The studies introduced in this volume communicate rich, contextual stories about the uses and possibilities of interactional ethnography to advance our language, knowledge and understanding of contemporary science and engineering classroom cultures and how these create opportunities for engagement, learning and identity building among diverse students and their teachers. The collective force of these academic narratives and their chronotopes evoke a more humane and nuanced approach to the investigation and understanding of educational processes and learning opportunities in science and engineering in situ. Rather than treating culture as a container, as an independent variable that influences engagement and learning, these studies treat culture as an interpretative and localized meaning-making process that enables participants to engage in different collective activities. In this approach, culture is defined as a situated resource—a fund of knowledge and a repertoire of practice—that learners draw upon in order to make sense of their social and material worlds and to participate in it. These studies also move away from individualistic and trait-like explanations of learning success and failure, to consider cultural continuities and discontinuities in situ, across space and time. By emphasizing both processes of acculturation and transformation, many of the chapters in this volume are positing an agentic learner whose capacities are afforded and constrained by the discourses, knowledge, cultural practices and tools they can access within their social setting. The studies also imply how science and engineering education is always a normative and ethical endeavor, affording or constraining access to value-laden discourses, practices and resources that affect the level and kinds of participation that individuals might achieve (Kumpulainen & Renshaw, 2007; Renshaw, 2013).

Whilst following Bakhtin's formulation of chronotope, Kamberelis and Dimitriadis (2005) have pointed out that all research efforts arise through human activity within a particular time and place that "delimit the objects worthy of investigation, the research questions that may be asked, the units of analysis that are relevant, the analyses that may be conducted, the claims that may be made about the objects of investigation, and the forms of explanation that may be invoked" (Kamberelis & Dimitriadis, 2005, p. 24). In this volume, we are introduced to a set of empirical studies of contemporary science and engineering education, whose logic-of-inquiry rests on the interactional ethnography approach. Whilst each study is also unique in its focuses, and addresses different

topical issues in science and engineering education, a common thread across the studies is their attempt to coordinate analysis of both individual actions and collective practices across space and time, as well as their efforts to make sense of part-whole relationships and micro-macro level dynamics of educational processes as situated and socioculturally framed. Each study is characterized by multiphase, recursive and consequential data collection processes and analyses which are reported in systematic and transparent ways, resulting in generative and reflexive accounts guiding their way to the formulation of new research questions. Hence, these studies based on interactional ethnography open up new possibilities for discourse, knowledge and social practice in researching and understanding science and engineering education processes. The studies also highlight how the interactive ethnographic approach challenges the traditional role of the researcher and those taking part in research, illuminating the delicate and challenging processes of constructing an emic perspective of the research context(s) and the research phenomenon in question, and developing more co-participatory research relationships and arrangements with the research participants.

Drawing upon Bakhtin's notion of addressivity, we can ask "What audiences are addressed by the academic narratives shared in this volume?" Clearly, one prime audience of this volume is educational researchers interested in the study of discourse, knowledge and social practice in contemporary science and engineering classrooms, and the possibilities and consequences of these studies to advance educational theory and practice. The volume also speaks to teachers, curriculum developers and policy-makers about the situated conditions and processes of the construction of science and engineering concepts, processes and practices in diverse classrooms and among diverse students and teachers. As such, the volume creates powerful narratives for professional development and educational change. At the same time, this volume illuminates what it entails to conduct educational research based on the interactional ethnography approach, and the expressive potential of its language, concepts and social practices for educational research, educational opportunity and educational change (Strike, 1974). The chapters also make clear that there is a history to each of these articles reflecting personal and professional journeys of the authors in their production, thus making educational research human and situational.

While my interest is not to attempt to judge any of the studies and their merits, nor to argue in favor of the interactional ethnography over other research approaches, I would like to conclude my commentary by underscoring one feature in these studies and the whole volume what I find highly compelling and important, and worthy of attention. This is to do with the notions of stabilization

knowledge and possibility knowledge, and their use and production in educational research on science and engineering education (see also Engeström, 2007).

Stabilization knowledge accounts for knowledge that is constructed and used by individuals and collectives in order to make sense of complex reality that is constantly shifting and changing. Stabilization knowledge is typically used to access and categorize a phenomenon so that it can be registered and dealt with. An illustrative example of stabilization knowledge in use is the labelling of handicapped students, as pointed out and challenged in the classical study of Mehan and his colleagues (Mehan, Hertweck, & Meihls, 1986). Although such narrow and one-sided categorizations are at times needed - just like in the story of seven blind mice who all came up with their solution to the strange Something – these categories unfortunately often turn into fixed and simplified labels for phenomena, including human beings, social practices and learning.

Possibility knowledge, on the other hand, emerges when objects and/or phenomena are approached in ways that allow access for their situated meanings as part of everyday interaction, movement and transformation. The generation and use of possibility knowledge has the power to destabilize knowledge and put it in movement which can again open up new possibilities for discourse, knowledge and social practice. In this sense, possibility knowledge is agentive, future-oriented, and generative (Engeström, 2007). As the studies in this volume demonstrate, interactional ethnography has many characteristics that offer potential instrumentality to educational research towards the generation of possibility knowledge in science and engineering education. The logic of inquiry of interactional ethnography invites researchers to take seriously the local ways in which discourses and social practices and their meanings are constructed over time in classrooms and their cultures, reflected in recognized ways of talking, being and knowing (Green & Castanheira, 2012). The research knowledge generated by interactional ethnography not only offers complimentary methods to study and make sense of science and engineering education but creates an expressive and reflexive language of justice and hope.

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